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TYPE CLASSIFICATION FOR MANAGING WESTERN WATERSHEDS

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INTERIOR WEST WATERSHED MANAGEMENT

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ABSTRACT

Habitat type classification systems are reviewed for potential use in watershed management. Information on climate, soils, and vegetation related to the classifications are discussed. Possible cooperative applications of vegetation and habitat type classifications to watershed management are explored.

Keywords: vegetation, classification, site, watershed management.

INTRODUCTION

Vegetative habitat type classifications are now widely used by silviculturists, wildlife biologists, soil scientists, and land-use planners in the Western United States. Considering the wide use and acceptance by several disciplines, it seems peculiar that watershed managers have not made greater use of the classifications in their management discipline.

In 1970, a small group of silviculturists and ecologists developed management implications for the Daubenmires' (1968) forest habitat types of northern Idaho and eastern Washington. The management guide included rankings by habitat types of potential water yield and of vegetative recovery following disturbance (Pfister 1976). This information received limited distribution and little response from watershed specialists. Perhaps watershed managers had either no use for potential water yield rankings by habitat types, or they considered watershed implications developed by silviculturists and ecologists unreliable. More likely, we failed to (1) communicate with watershed managers, (2) failed to understand their needs, and (3) failed to involve them in the rating procedure.

To provide a better basis for communication between ecologists and watershed managers I have developed this paper in four sections: (1) A brief review of habitat type classification concepts; (2) Status of habitat type classification in the Western United States; (3) A survey of kinds of vegetation, soils, and climatic information included in the classifications; and (4) Suggested opportunities for evaluating relationships between habitat type classification and watershed management.

THE HABITAT TYPE CONCEPT

Habitat typing as a means of classifying forest ecosystems (vegetation and sites) was first introduced by Rexford Daubenmire (1952) for northern Idaho and eastern Washington. In contrast to systems that classify current vegetation, this approach is based on classification of the **potential** climax vegetation. Climax (stable) vegetation reflects the overall environment as an integration of climate, topography, and soils. Successional trends toward climax can usually be identified even in relatively young stands. Thus, a given habitat type includes all land areas **potentially** capable of producing similar plant communities at climax; it does not necessarily reflect similarities in current vegetation.

Habitat types provide a permanent system of land classification that can be applied to both research and management activities. Field experiments can be stratified by habitat types, thereby aiding extrapolation of results to similar field conditions. General resource production capabilities have been developed for land-use planning based on habitat types (Pfister 1976). Although the system reflects an integration of physical environments, some correlations can be established with individual factors, such as temperature, soil moisture, precipitation, evapotranspiration, and so on.

In addition to site classification, the habitat type approach provides a classification of mature or near-climax plant communities with detailed information on species composition. General trends of succession are usually predictable for each habitat type. Responses of vegetation to management can be expected to be generally similar on units of land within the same habitat type if the current vegetative community and other variables are also considered. Although this system does not include a description of young seral communities, the site classifications and descriptions of mature communities provide a foundation for study of early successional stages.

The climax community type (association) provides a logical name for the habitat type—for example, *Abies lasiocarpa/Xerophyllum tenax* (subalpine fir/beargrass). The first part of the name is based on the climax tree species (usually the most shade-tolerant tree adapted to the site). We call this level of classification

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the **series**, and it includes all habitat types having the same dominant tree at climax. The second part of the habitat type name is based on characteristic undergrowth species in the climax community type. A third level (phase) is used when necessary to recognize subdivisions of a habitat type. Single species names are used for each level of the taxonomic hierarchy to keep nomenclature simple, yet diagnostic.

The habitat type taxonomy provides a basic foundation for wide usage of the system. Access to the classification is provided by a key, structured much like a key for identifying plants. A minimum of training in identification of a list of "indicator species" allows many users to identify the habitat type routinely in the conduct of their field work. These users of the system thus have the opportunity to tie their own data and observations to the classification framework.

The habitat type taxonomy also provides the basic criteria for ecotone recognition in the field and for the construction of habitat type maps. The resulting maps provide a permanent record of habitat type distribution on the landscape and a basis for acreage estimates for land-use planning.

The classification manual is intended for two audiences—managers and scientists. Its primary value is as a tool for communicating information about forest ecosystems.

STATUS OF CLASSIFICATION

Habitat type taxonomies have been developed for many areas in the Western United States (figure 1, table 1). Although each study has slight differences in techniques and terminology, the underlying concepts and resultant classifications are quite similar. Therefore, managers are able to use the classifications in similar ways. The data base is also uniform enough to allow correlation of types among different geographic areas.

Habitat type mapping has progressed rapidly in Montana and Idaho. Habitat type maps at a scale of 1:31,680 (2 inches/mile) have been completed for many large (20,000 to 100,000 acres) planning units (Layser 1974). Several entire National Forests (1 to 2 million acres) have been mapped at this scale (for example, Deitschman 1973). Detailed maps have been prepared for several experimental areas (for example, Daubenmire 1973) and are often made by foresters as part of silvicultural prescriptions and other project plans. The scale used for detailed mapping is usually 1:15,840 or 1:7,920 (4 inches or 8 inches/mile), with estimated accuracies usually exceeding 90 percent. These maps are permanent and can be used for many future interpretations in addition to those for which they were originally developed.

INFORMATION IN HABITAT TYPE CLASSIFICATIONS RELEVANT TO WATERSHED MANAGEMENT

General Site Factors

Vegetation is an integrated expression of environments; we can expect individual physical factors to vary within a habitat type. On the other hand, geographic location, elevation, aspect, topographic position, and general soil characteristics are considered during final resolution of types (Pfister and Arno 1980). If a proposed type cannot be related to general site characteristics, appropriate revisions in the classifications are considered.

Site characteristics are summarized in habitat type descriptions or in tabular form. The summaries illustrate the range in certain site variables and provide benchmark points to help characterize and understand the classification system. Summaries are of course limited to factors that were recorded during the field sampling.

Vegetative Information

Certain characteristics of vegetation described in habitat type classification may be useful for watershed management. Measures of tree components (stand density, canopy coverage, and stand structure) relate to interception, evapotranspiration, snow accumulation, and snowmelt. Measures of undergrowth vegetation (species composition and cover) also may relate to water relations and erosion potentials. Unfortunately, the vegetation descriptions are only available for mature and old-growth communities. Nevertheless, they provide general guidance for the kinds of communities to be expected as different successional stages within different habitat types.

Soils Information

Soils information included in habitat type classifications is usually inadequate for some watershed interpretations. Some investigators obtain a complete profile description for each sample stand; others obtain only minimal soils data. Correlation of habitat types and soil types (based on standard taxonomic procedures) is usually too weak to allow prediction of one from the other (R. and J. Daubenmire 1968; Pfister and others 1977). On the other hand, certain soil features (not

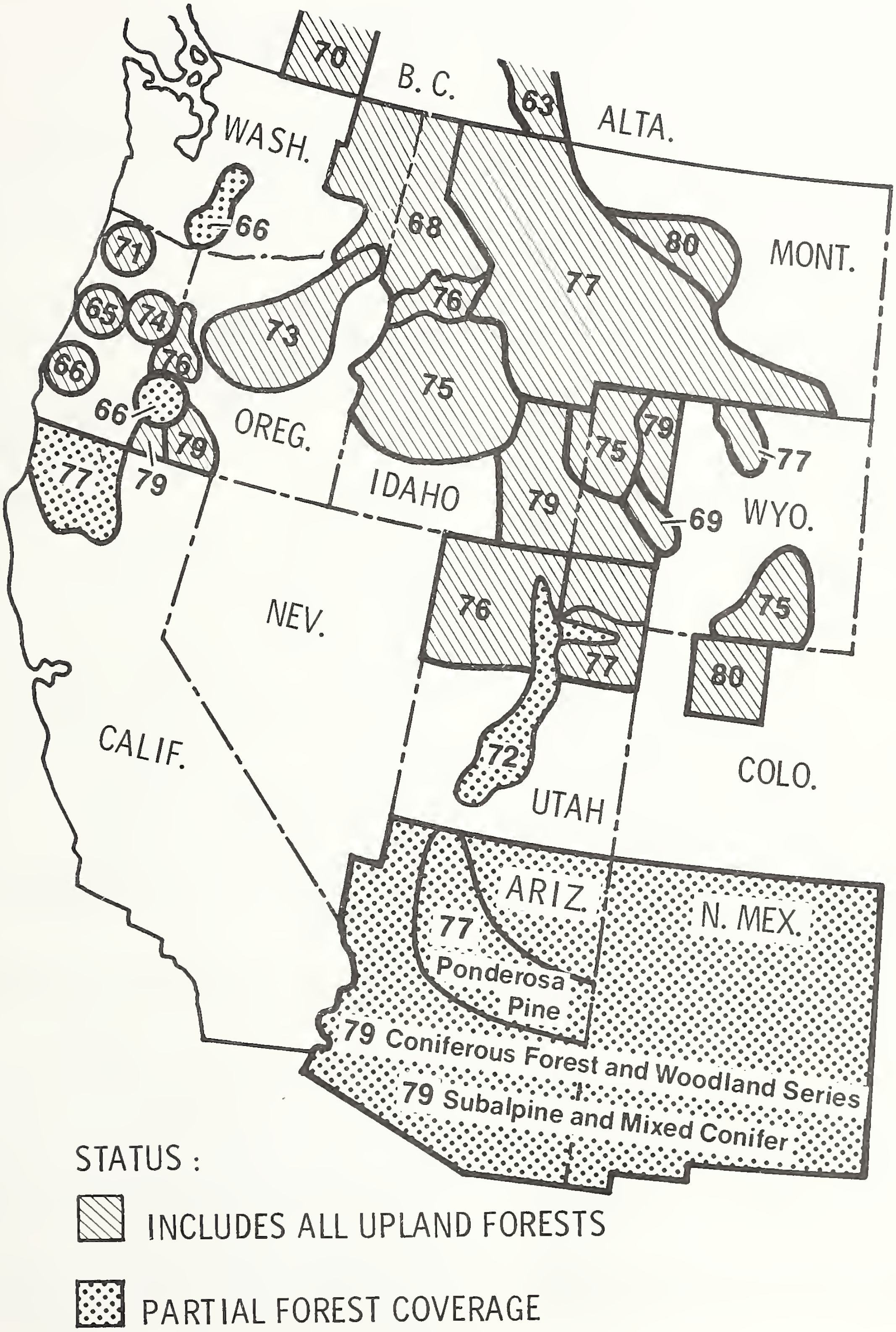

Figure 1. Forest habitat type classifications available in the Western United States. (Numbers refer to year when published or distributed to users. References are listed in table 1.)

Table 1. Forest habitat type classifications available in the Western United States (listed chronologically and shown in figure 1 by year completed).

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necessarily reflected in soil taxonomy) may show good relationships to habitat types. Some habitat types show a strong relationship to parent material, especially calcareous versus noncalcareous substrates. Several habitat types are restricted to sites having water tables close to the surface during part of the year. Other features such as extreme textures, rockiness, and litter accumulation may show general relationships to the habitat types.

In view of variable information content on soils and the operating principle of factor interaction, caution is urged before extrapolating soils-habitat type relationships from one area to another. Each classification in table 1 must be evaluated individually for specific expressed relationships to soils that may be useful for watershed management.

Climatic Data

Several of the habitat type classifications in table 1 include auxiliary climatic data than can be interpreted for watershed management. For example, Daubenmire and Daubenmire (1968) provide climatic summaries from weather stations representing major classes of forest vegetation types. Data on temperature, precipitation, and evapotranspiration illustrate differences between type classes. Pfister and others (1977) present summaries from several climatic stations that are identified by the appropriate climatic climax habitat type and phase. Daubenmire (1970) also compares climatic data (referenced to several steppe zones) to several climatic classifications. Although the universal climatic classifications did not correlate well with the vegetative-based classification, certain individual climatic parameters (related to water balance) helped quantify differences among vegetative zones.

Inferred Relationships

Ecologists usually hypothesize the relationships of types to major environmental gradients. Habitat types are portrayed relative to each other as warmer or colder, drier or wetter, etc. These relationships are included in the written descriptions or displayed in illustrations. Gradient analyses have also been used to generate and display these hypotheses. One example is the indirect ordination produced by Dyrness and others (1974) where plant associations are arranged along inferred temperature and moisture gradients for the H. J. Andrews Experimental Forest. The inferred relationships were later tested by measurements of temperature (degree days) and plant moisture stress. Correlations between inferred and measured environmental gradients were generally good (Zobel and others 1976).

Inferred relationships are an attempt to explain the most important environmental factors giving rise to the classification units. However, such relationships must be regarded as hypotheses until quantitative data can be collected to test them. Nevertheless, until the relationships are quantified, the hypothetical relationships are better than no information at all. In some cases, the hypotheses are sufficient for some broad management decisions. For example, definite management implications can be drawn for habitat types that reflect high water tables.

OPPORTUNITIES FOR DEVELOPING ADDITIONAL RELATIONSHIPS

Quantifying Environmental Factors

In the process of developing a habitat type classification, it is usually impossible to quantify all of the physical site factors. Rather than bemoan this fact, we can look on the classifications as a first step to studying and interpreting the relationships between vegetation distribution and environmental gradients. Ecologists look at temperature, moisture, and other factors to understand vegetation-environment relationships. Other disciplines, such as watershed management, look at the same physical factors to explore other relationships. A review of some areas of concern may illustrate opportunities for future cooperation.

Ecologists and watershed specialists are both frustrated by lack of site-specific environmental data for large areas of land. Conclusions must be reached by extrapolations from a small number of sites having continuous data. Maps of isotherms and isohyets have been developed from general relationships with topography and geography. Another approach for extrapolation may be through quantifying environmental factors in relation to the habitat types. What has been done to quantify these relationships and what might be done in the future?

Numerous studies have shown that the major factors related to vegetation distribution and type patterns involve temperature, moisture, available nutrients and mechanical stress. The relative importance of these factors varies from area to area. Literature reviews on this subject area are available (e.g., Daubenmire 1956; Waring and Major 1964; Zobel and others 1976), but specific examples from our area may be more illustrative.

Annual patterns of soil moisture depletion are the dominant site factor related to vegetation patterns in steppe vegetation and in the *Pinus ponderosa* and *Pseudotsuga menziesii* habitat types in the Northern Rocky Mountains (Daubenmire 1968, 1972; McMinn

1952). In more mesic environments, temperature plays a dominant role (Daubenmire 1956). Similar relationships in the Oregon Cascade Range were documented by Dyrness and Youngberg (1966) and Zobel and others (1976). Geologic substrate and soil-water relationships are two major factors determining vegetation pattern in the Big Horn Mountains of Wyoming (Despain 1973). Several of the classifications in table 1 include U.S. Weather Bureau data on climate, with the weather stations referenced to some level of the classification. Arno (1979) listed climatic data from 16 weather stations (referenced to "series" level of classification) as part of the basis for defining forest regions of Montana. Weaver (1980) summarized data from 114 U.S. Weather Bureau Stations in relation to 12 potential natural vegetation types of Kuchler (1974). From these (and other studies not cited) one might conclude that the relationships have been adequately researched. However, considerable opportunity exists for further study that would benefit both ecologists and watershed managers. What kinds of studies are needed?

Future studies of vegetation-environment relationships would benefit from more rigorous attention to hypotheses formulation and data requirements. At least two objectives can be considered that should be compatible:

(1) To improve understanding of ecological cause-effect relationships.

(2) To provide quantitative summaries of physical site factors for each unit of a classification system as a basis for interpretation and application.

Ecologists form informal hypotheses as they develop their classifications. Formal statement of these hypotheses would improve understanding of the classification and provide testable hypotheses. Formal hypotheses could also be developed jointly by watershed specialists and ecologists. If adequately documented, they could serve as state-of-the-art expert opinions and as a basis for new studies to test the most important relationships.

Available sources of data should be utilized more completely than has been done in previous studies. U.S. Weather Bureau Stations, environmental monitoring sites, fire weather stations, storage-gage precipitation sites, snow survey courses, "barometer watershed" stations, and field research studies are all sources of data for quantification. However, careful site description is essential **before** analyses are conducted. For example, merely identifying the habitat type of a weather station site is not sufficient. Onsite evaluation of the topography, soils, and local pattern of type distribution is essential to ensure correct interpretation of vegetation-environment relationships. Factor interaction must be considered at the outset; one means to do this is to evaluate the specific site according to the polyclimax concept of Tansley (1935). Specifically, onsite interpretation is needed to determine the degree to which potential vegetation of a site reflects a climatic, edaphic, or topographic climax. This requirement will help ensure proper interpretation of climatic data in relation to vegetation patterns. In essence, this approach to quantifying environmental factors requires defining the relative importance of specific site factors and determining their interactions.

One should also consider the need for supplemental data and the kinds of measurements and analyses conducted. For instance, weather station data might be supplemented by evaporation and soil moisture data for a long enough period of time to establish correlations for individual sites. There are also many ways of summarizing continuous weather data. Analyses should be directed at critical measures or periods deemed most appropriate to questions being asked. A thorough review of climatic variables in relation to vegetation distribution has been provided by Daubenmire (1956); it is highly recommended for study prior to undertaking new investigations of climate-vegetation relationships.

Soil moisture can be measured and expressed as (1) quantity of water available, (2) soil moisture stress, or (3) plant moisture stress. The latter two may provide the best correlation with vegetation; whereas, the first one may be of greatest interest to a hydrologist. Correlation of various measures should be provided to aid interpretation and application.

Quantification of environmental factors will aid understanding and improve application of habitat types to watershed management. However, many past studies have been superficial with inadequate attention to detail and inadequate characterization of study sites. Studies of factor interaction must be recognized as a complex task, not simply a summary of existing data.

Hydrology-Vegetation Relationships

Watershed managers are concerned with evaluating the effects of land management activities on the hydrologic cycle and related impacts. Some hydrologists in the USDA Forest Service Northern Region have developed a vegetative hydrologic recovery index based on estimated rates of secondary succession following disturbance in different habitat types. This index is interpreted for water yield and potential erosion in relation to time since disturbance. (For example, see 1980 Proposed Lolo National Forest Plan, appendix B-7e.)

Accumulation of knowledge and increased emphasis on watershed management have stimulated development of hydrologic simulation models (Leaf 1975). Although current models are very generalized, future modeling efforts could be linked to habitat types for improved precision. This of course, assumes that physical site factors relating to habitat types will be accumulated and summarized in a form suitable for use in hydrologic models.

Habitat type classifications do not currently provide sufficient vegetation information on early successional stages for input to hydrologic models. On the other hand, several studies are currently underway to define plant community composition at various successional stages. For example, Bartos (1973) has developed a vegetation model of aspen-conifer succession. Jaynes (1978) subsequently developed a related hydrologic model to express the effects of aspen-conifer succession on water yield. Each model contributes to multiple-use planning and in combination they complement each other.

Numerous factors in hydrologic models are related to vegetation. Thus, it behooves ecologists to present their vegetation data in a form useable as input to hydrologic models. Likewise, it behooves hydrologists to examine vegetation data of ecologists as possible input for hydrologic models. If we agree with Huff (1971) that ecosystem hydrology assumes complex interactions between the ecosystem and the hydrologic cycle, then we should also agree that close teamwork between hydrologists and ecologists is imperative and would provide mutual and synergistic benefits.

Mass Movement and Erosion

I do not know of any studies that directly relate habitat type classifications to slope instability or mass movement. However, Pole and Satterlund (1978) recently reported that 15 understory plant species showed a preferential occurrence on unstable sites. The authors also cited several other studies where vegetation or individual species indicate excess soil moisture. Interestingly, many of their 15 indicator species are being used as habitat type or phase indicator species in recent classifications of adjacent areas (Pfister and others 1977; Steele and others 1981). The habitat types and phases with high water tables usually occur on gentle terrain not susceptible to mass movement. Nevertheless, the occurrence of such types and phases on steeper terrain would be a potential indicator of slope instability. Cooperating ecologists and soil scientists may be able to predict slope stability from combinations of habitat types, slope steepness, soils, and geomorphologic characteristics. A state-of-the-art user's manual could be prepared for field use in locating roads, trails, and other projects to minimize landslide hazards.

Erosion relationships are also usually excluded from management implications in habitat type classifications. The closest information provided would be relative rates of vegetative recovery following disturbance. These recovery rates have been used for watershed interpretation in a general way. However, as work continues on describing successional stages within habitat types, we can look forward to more precise estimates of kinds and amounts of vegetation development following different kinds of disturbance.

It is still common practice to seed grass on wildfire areas with little consideration of probable natural revegetation potential on different sites. The data of Klock and others (1975) suggest major differences in establishment of some species with regard to habitat type. Summarizing data on seeding success of native and "introduced" species in relation to habitat types should lead to site-specific seeding recommendation. The knowledge base could also be expanded by identifying habitat type on all new field studies and seeding trials.

SUMMARY AND CONCLUSIONS

1. Habitat type classifications are available for many forest lands in the Western United States.

2. The classifications provide both (a) a taxonomy of potential natural vegetation and (b) an ecological site classification tool.

3. Information on climate, soil moisture, and vegetation parameters is being accumulated by ecologists; some of this new information may be useful for watershed management.

4. Ecologists and watershed specialists have many common interests in studying the interactions between physical factors of the environment and vegetation. Improved communication and coordination could provide significant mutual gains in knowledge and management.

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